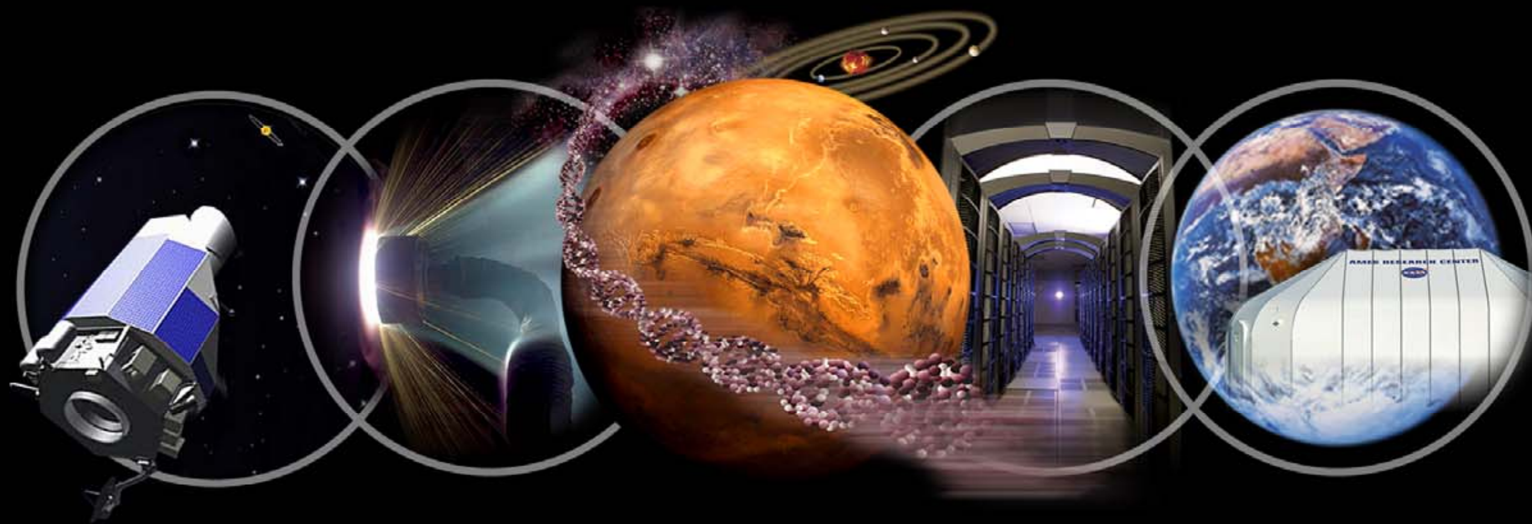
Discovery ➲ Innovation ➲ Solutions



Advanced Concepts and Analog Mission Campaigns

Geoffrey Briggs
650-604-0218 Geoffrey.Briggs@nasa.gov

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Visibility ➲ Excellence ➲ Impact

Ames Research Center

Advanced Concepts and Analog Missions

Many innovative concepts for both robotic and human space exploration emerge from Ames because of its interdisciplinary expertise in Space Science/Information Technology/ Aero and Entry Technology and because it is the home of numerous creative advocates of human space exploration

In addition, in the last decade Ames and SETI Institute researchers and colleagues have conducted an increasingly ambitious program of analog missions -- science and technology initiatives in a variety of terrestrial analog sites -- Canadian Arctic, Antarctica, Siberia, Hawaii, Mojave, Utah, and Chile; we view such analog research as being fundamental to preparing for the Space Exploration Vision in a safe and affordable way (and one that maintains strong public support)

Analog Missions Campaigns

- The President's Space Exploration Vision is very ambitious and *greatly* exceeds the nation's present capabilities
- Further, the program will unfold over decades within a constrained budget
- Therefore, NASA has a lot of learning to do regarding astronaut exploration of other planetary surfaces -- in terms of crew safety, efficiency and cost-effectiveness -- while continuing to engage public interest and while developing the needed experience in an affordable way
- Terrestrial analog missions can combine scientific exploration, technology development, crew and operations team training, and can directly engage the public thereby helping to solve this problem

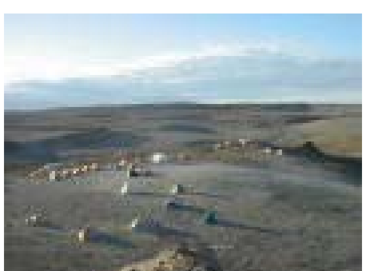
Understanding Testing Training

Issues re human exploration requiring creative solutions (where Ames can help)

- Optimum role of Moon as precursor to human Mars exploration
- Gaining access to volatiles lying within permanently shadowed areas near the lunar poles
  - Ultra-cold temperature technologies vs directional drilling from illuminated site
- Transportation of landed assets over 100's meters from safe landing zone to ultimate desired position in base complex
  - Trade study: self-mobile habitats[1] vs. heavy duty teleoperated tractor vs winch
- Potential long distance relocation of base assets to new sites
  - Potential of self mobile habitats[1]
- Accumulation of sufficient human experience with artificial gravity[2] in time to use on long duration deep space missions
  - Schedule requirements imply need for early start to in-space experiments
- Potential use of regolith as shielding for habitats
  - Systems problem with potential teleoperations/robotic contribution[3]
- System solution to backward planetary protection concerns when astronauts gain access to martian ecological niches unavailable to robotic precursors
- Controlled *land*ing of Crew Exploration Vehicle[4]
- Optimum roles for humans and robots

1. mcohen@mail.arc.nasa.gov
2. llemke@mail.arc.nsa.gov
3. Michael.H.Sims@nasa.gov
4. layoung@mail.arc.nasa.gov

Analog Missions: A Brief History



Haughton Mars Project

- Since 1997 an increasingly ambitious series of combined science and technology projects have been carried on Devon Island at the site of a 23 million year old impact event that created a 20 km diameter crater in Paleozoic sediments and excavated material from a depth of over 1.7 km
- Scientific experiments have been carried out in parallel with technology demonstrations: habitat, laboratory local communication networks, satellite communications to ARC and JSC, human transportation, robots, simulated advanced surface robots controlled from ARC's Future Flight Central, aerial robots, greenhouse, unpressurized space-suits, drill …

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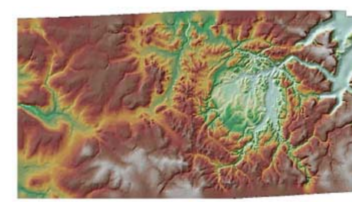



BEES for Mars Flyer Ready for Launch. Larry Young and

pclee@earthlink.net

System of Systems Demonstrations

- Emplacement of prototype spacecraft habitats, laboratories, power systems etc. for spiral development is highly affordable and safe compared to in-space deployment
- Such completeness in approach is an ideal way of understanding all the **system-of-system** implications of long duration missions in deep space

  Habitats/habitat mobility, laboratory, greenhouse

  closed life support

  power and its distribution

  communications

  EVA, transportation, human-robot roles

  crew size/skills, diurnal cycle, changing time delay

  planetary protection, lab automation

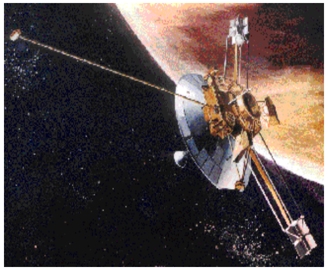
  human factors …..
- Astronaut training takes place alongside hardware development
- Eventually end-to-end planetary surface missions can be simulated in great detail and crews/controllers, through their training, can demonstrate their safety and effectiveness *as a team*

Analog Missions and the H&RT Program

- Arguably, all new exploration technologies needed for lunar and Mars surface missions should be (and may well be required to be) demonstrated first in terrestrial analog environments
  - System Level
  - Systems of Systems
- Ames has been developing relevant expertise for many years -- exploration technologies, logistics and communications -- and can make this available to H&RT proposal partnerships
  - Devon and Ellesmere Islands in the Canadian Arctic
  - Western US deserts (California, Arizona, Utah, Nevada)

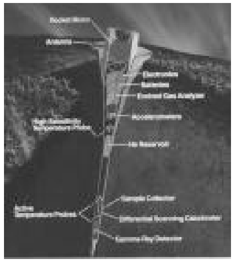
pclee@earthlink.net
Geoffrey.Briggs@nasa.gov

Advanced Concepts: Some History



Pioneers at
Jupiter & Saturn

Pioneers at Venus

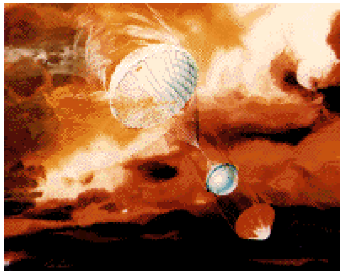


CRAF Penetrator

Mars Observers

Mars Airplane

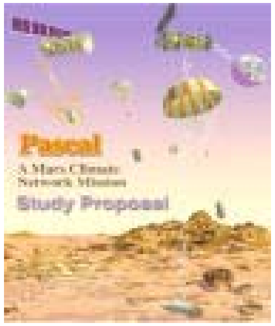
MESUR



Jupiter probe

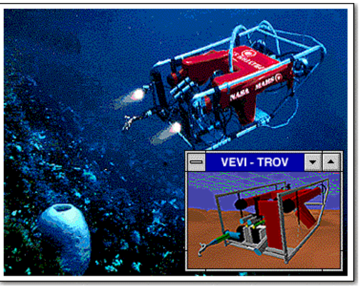
IRAS

SIRTF



Mars Meteo
Network

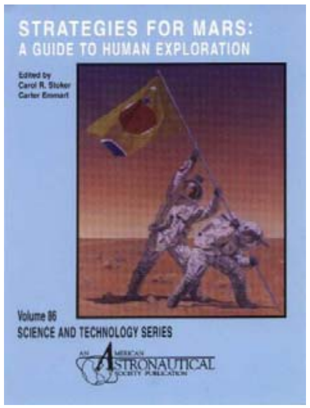
Mars Rotorcraft

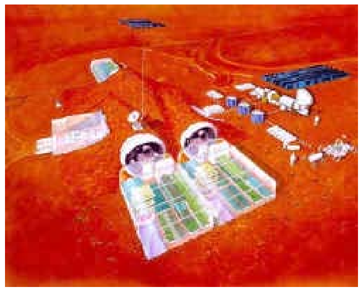


Virtual Reality
Mobile Robots

Ames Human Exploration Advanced Concepts

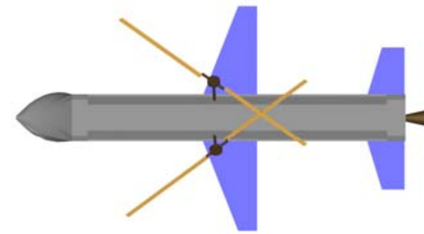
Case for Mars Studies





Mars Greenhouse

Rotary Wing Re-entry Vehicles



Artificial gravity

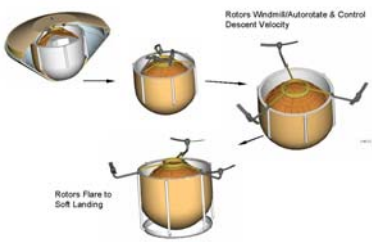
Aspects of
Mars Design Reference Mission

Human-Robot Field
Science: VR control

Terrestrial Analog:
Haughton Mars Project

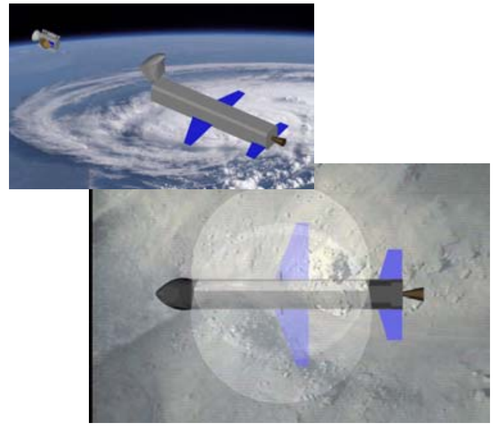
Aero-based Advanced Concepts

Mars Rotorcraft
- ASTEP Proposals
- Vision Mission Proposal



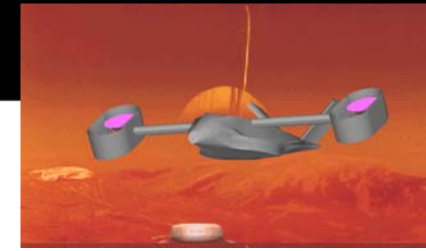
Venus Probe RW Decelerator
- FY04 DDF Proposal
- Codes S, A, and I Co-I's

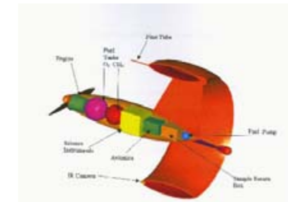
Outer Planet Robotic Gliders
- FY04 DDF Proposal; Codes S, A, and I Co-I's
- Potential tie-in with Vehicle Systems Program



Rotary-Wing Reentry Vehicles
- Consultation on JSC Roto-Capsule Concept
- FY04 DDF Proposal; Codes S, A, and I Co-I's

Intelligent Systems Aerial Explorers
- FY02-03 BEES for Mars effort
- FY04 Mission Architecture Feasibility Study





Titan VTOLs
- FY03 MUREP Student Design Competition
- Follow-on Related Competition in discussion

Air-Deployed Tetherbots
- FY04 DDF Proposal; Codes A and I
- Builds upon BEES for Mars UAV work

layoung@mail.arc.nasa.gov

Planetary Protection in Era of Human Exploration

- Rigorous backwards planetary protection will be an expensive enabling technology for Mars Sample Return because NASA has unique requirements -- to simultaneously protect the environment and the samples
- Robotic MSR will be limited to sampling the heavily irradiated, arid near surface environment
- Human explorers will be able to gain access to more protected environments (e.g., deep subsurface) where water may be available
- Thus human missions face a *much greater PP challenge*
- A sample handling laboratory will likely have to be separate from the crew habitat, highly automated and using Robonaut like devices for operations
- Demonstration of this capability on the Moon or at a terrestrial analog site may be essential

Geoffrey.Briggs@nasa.gov

Mars Astrobiology Rio Tinto Experiment

(NASA ARC& JSC, CAB (Madrid), U. Oklahoma, Honeybee Robotics)

Search for a subsurface biosphere at Rio Tinto Spain using human tended and robotic drilling yielding important lessons for drilling missions to search for subsurface life on Mars- both robotically and with humans. New exploration technology includes:

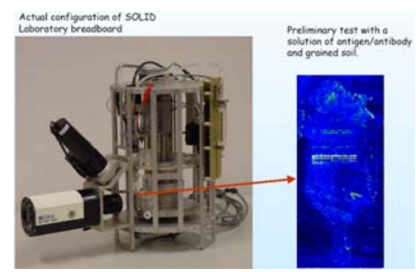
• Robotic drilling
• Robotic core and sample handing
• Remote sensing and instrumentation for life detection

Science yield to date:

• Previously unknown subsurface biosphere living on iron and sulfur minerals and producing acidic conditions and sulfate minerals lime Opportunity discoveries

Mars Drill Technology

Downhole Instruments

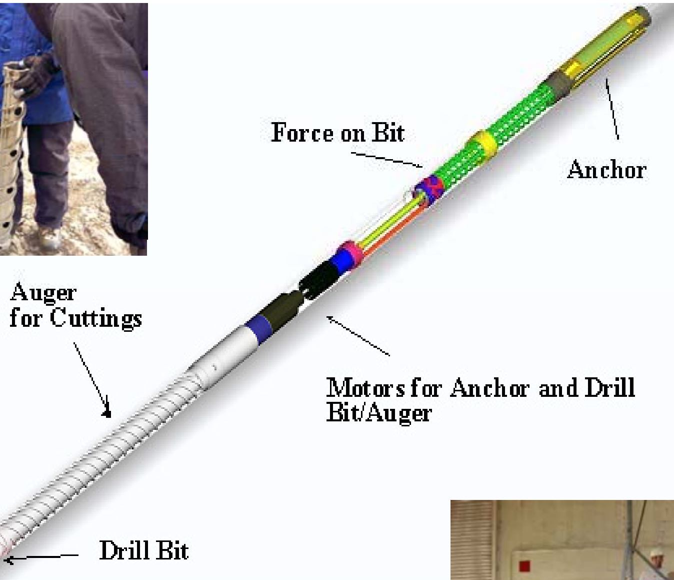


Life Detection Instruments

cstoker@mail.arc.nasa.gov
hcannon@mail.arc.nasa.gov

Mars/Arctic Deep Drill Development (ASTID Project)

NASA ARC and JSC, Baker Hughes, UC Berkeley, UTexas, LPI, McGill U



The project is developing a prototype lightweight (<20 kg) low power (50 watt) dry drill for astrobiology application in the Arctic and on Mars. The goal is to demonstrate in an appropriate Mars analog environment a drill capable of retrieving samples from the martian subsurface to depths of hundreds of meters

Geoffrey.Briggs@nasa.gov